Investing in paintings, sculptures, photography, and prints: what we know about price bubbles in those markets

Abstract: This article employs the GSADF test and phi correlation coefficients to investigate the occurrence and co-occurrence of price bubbles across 25 indices representing the art market. These indices include four segments of the art market: paintings, sculptures, photography, and prints. The analysis covers monthly data from June 1985 to July 2024.

The most significant findings of the study are as follows. First, the occurrence of periods identified as price bubbles was confirmed across all 25 indices examined. This was demonstrated with the highest significance level set at α=0.01. It was also shown that there is considerable variation in the duration of price bubbles among the indices studied, ranging from less than 10% (for the Prints German OM and Prints French 19th indices) to over 50% (for the Photography E&A, Photography American, and Sculpture Euro & NA indices). The overall average duration across all indices was 28.9%. Additionally, it was observed that the art market tends to experience positive co-occurrence of price bubbles. In most pairs of indices examined, the phi correlation coefficient was positive, with an average value close to 0.30. Furthermore, no significant co-occurrence of price bubbles within the same groups, such as paintings, sculptures, photography, and prints, was confirmed. The Photography British 19th index was also notable for its role in investment portfolio diversification, as it often displayed the lowest (sometimes negative) phi correlation coefficients.

Key words: price bubbles; generalized supremum ADF test; art markets; co-explosivity

JEL classification: E3; G11; G12

1. Introduction

The art investment market exemplifies broadly understood alternative investments (Jurevičienė & Jakavonytė, 2015). It falls into the category of investing in passions (Plastun et al., 2022), characterised by the receipt of the so-called aesthetic dividend (Campbell, 2008), which involves the investor's opportunity for communion with the object of investment. On one hand, the value of annual turnover

in the art market has consistently surpassed 50 billion dollars since 2021 (McAndrew, 2025). On the other hand, in the past two years, the market's value decreased by 4% in 2023 and by 12% in 2024. Despite the decline in sales value, the number of artworks sold has continued to rise since 2021. Growing interest in art investment is primarily driven by the increasing number of wealthy investors (UBS, 2025) seeking secure methods to grow their wealth. This trend is especially prominent during times of turmoil in financial markets, which tend to focus on traditional investment avenues such as stocks and bonds. When traditional markets encounter unforeseen events—like the outbreak of COVID-19 in 2020 or Russia's full-scale invasion of Ukraine in 2022—the art market often becomes one of the safe havens (Śmiech & Papież, 2017), achieving record results in turnover and investor interest.

Previous scientific research on the art market has concentrated on examining the relationship between the rates of return obtained in the art market and other forms of capital growth (Campbell, 2008), constructing indices that reflect changes in the art market (Marinelli & Palomba, 2011), or analysing price volatility in this market (Bocart & Hafner, 2012). Little attention has been given to researching the occurrence of price bubbles in the art investment market. The few studies in this area are discussed in the next part of the article. Furthermore, there are no studies on the simultaneous occurrence of price bubbles across different types of investments in this market.

Considering the main disadvantage of investing in art, namely the low liquidity of this market (Mei & Moses, 2002), studying the occurrence and co-occurrence of price bubbles appears justified given the market's size. The insights gained from such research will be valuable not only for individual and institutional investors but also for market analysts or investment fund managers. Furthermore, the findings from this analysis should also benefit institutions that regulate the investment market. This is because the formation and bursting of price bubbles primarily lead to negative effects, ranging from smaller impacts, such as the negative welfare effect (Su et al., 2020), where the wealth of smaller investors diminishes while the wealth of the affluent increases, to more severe macroeconomic consequences like the financial crisis of 2008 (Brunnermeier et al., 2020; Jarrow & Lamichhane, 2021).

This study first aims to determine whether the art investment market, represented by 25 price indices, includes periods that can be identified as price bubbles. Next, these periods are characterised for each index by the number of price bubbles and their average duration, with these findings compared to other studies on different investments. Finally, it investigates whether price bubbles occurred simultaneously across different pairs of the studied indices.

The following sections of the article present the conclusions from the most significant literature studies on detecting price bubbles in the art investment market. Then, the data used for the study and the

research methods employed are described. The next step is to outline the obtained results, and the entire article concludes with a summary.

2. Literature review

Only a few studies have addressed the issue of price bubbles in the art market. One such study is the work (Assaf, 2018). In this study, data from the Artfact and Artprice portals were used to examine the occurrence of price bubbles across 15 indices, including investments such as 19th-century Art, Contemporary Art, Drawings, Modern Art, Old Masters, and Paintings. The Markov Switching ADF test did not confirm the presence of price bubbles in the examined indices, whereas the GSADF method did confirm multiple bubbles. Most bubbles were identified between 2002 and 2005. The analysis was based on quarterly data covering 1998 to 2015. The work also highlighted the growth of the art investment market to levels similar to other popular alternative investments.

A similar end for the research period was adopted in the subsequent study (Kräussl et al., 2016), which examined art market indices from 1970 to 2014. This article analysed indices such as Impressionist & Modern Art, Post-war & Contemporary Art, 19th Century European, and Old Masters. The research method employed in this work is the SADF test. It is not the most recent and most powerful version of the ADF family of tests for detecting price bubbles; currently, the most widely used is the GSADF test, which was utilised in this study. Despite using the SADF method, the authors state, "We identify two historical speculative bubbles and find an explosive movement in today's "Impressionist and Modern", "Post-war and Contemporary", "American", and "Old Masters" fine art market segments." An additional limitation of this study is that it relies on annual data.

In the next work, (Bernales et al., 2022) examine how artist deaths and collectors' wealth are connected to art price bubbles. Their findings suggest that speculative price bubbles often arise as a consequence of artist death. A similar pattern is observed when a negative relationship exists between collectors' wealth and the emotional value of artworks. Additionally, two smaller research articles focus on price bubbles in local art markets in South Africa (Binge & Boshoff, 2021) and in China (X. Li et al., 2020).

To the best of the Author's knowledge, no other works focus on the issue of price bubbles in the art market. Therefore, there is no study that is comprehensively based on conclusions from analysing numerous indices representing different segments of the art market. Moreover, such studies have not been carried out with data at a monthly frequency over such a long research period. Additionally, this study is not limited to examining price bubbles for the indices studied, but also addresses the problem of their co-occurrence, which has not been explored in previous works.

3. Data and methodology

The study utilised art market price indices obtained from Art Market Research [AMR] (Art Market Research, 2024). AMR is a leading provider of indices that illustrate shifts in sentiment within art markets. It collaborates with companies such as CHRISTIE'S, Knight Frank, HM Revenue & Customs, Sotheby's Institute of Art, Wall Street Journal, Credit Suisse, Financial Times, and The Art Newspaper. All indices used in this study were acquired as part of the "Miniatura 8" research grant. In total, 25 indices were analysed, covering four main sectors of the market: paintings, sculptures, photography, and prints. The period during which these indices were quoted spans from June 1985 to July 2024. During this timeframe, 470 monthly observations were examined for each index, which constitutes an exceptionally long research period for the art market to date. The choice to utilise data from AMR was driven not only by the availability of a long research horizon at a monthly frequency but also because their data have previously been employed in other studies on the art market (Boyer, 2011; Campbell, 2008). The full names of the indices analysed are provided in Appendix 1.

To present the raw data used in the study, Table 1 displays the main descriptive statistics for the analysed art market indices.

Table 1 Values of descriptive statistics for the art indices studied

No.	Art Index name	Mean	Median	Standard Deviation	Kurt.	Skew.	Min.	Max.	JB_Statistic
1	P. Art 100	7574.79	5759.00	4264.28	-1.57	0.24	1389.00	15212.00	52.55 ***
2	P. Contemporary Art	12511.01	7649.50	9022.11	-1.44	0.43	1344.00	30009.00	54.72 ***
3	P. European 19th	6255.31	5231.00	2544.88	-0.88	0.46	1958.00	12701.00	31.77 ***
4	P. Modern Art	10128.66	6384.00	7101.15	-1.35	0.48	1657.00	25466.00	53.6 ***
5	P. Modern European	7313.82	6688.50	3697.32	-0.97	0.45	1618.00	16541.00	34.51 ***
6	P. Old Masters	6051.85	5042.00	2582.84	-1.27	0.29	1691.00	11009.00	37.96 ***
7	S. American 20th	13929.88	8798.00	10283.06	-1.19	0.51	2464.00	39459.00	47.71 ***
8	S. British 20th	14395.81	9832.50	9424.91	-0.88	0.67	3550.00	36920.00	50.06 ***
9	S. Euro. & NA	4291.62	2784.50	2751.77	-0.62	0.92	1350.00	10284.00	74.64 ***
10	S. French 19th	4894.73	2802.50	3872.70	0.66	1.29	1391.00	16120.00	139.45 ***
11	S. French Animalier	2518.41	2250.50	1101.50	2.63	1.48	759.00	6811.00	310.75 ***
12	S. Italian 20th	3028.01	2733.00	1522.27	0.06	0.84	691.00	7257.00	55.18 ***
13	Ph. American	25829.13	19209.00	16241.80	-1.58	0.18	4034.00	51868.00	51.22 ***
14	Ph. British 19th	10721.81	10142.00	6392.07	-0.78	0.42	1919.00	25496.00	25.33 ***
15	Ph. Contemporary	67318.87	72401.50	36780.49	-1.28	-0.08	6067.00	142130.00	32.15 ***
16	Ph. E&A	19754.49	13760.00	12521.17	-1.54	0.23	2985.00	39430.00	50.39 ***
17	Ph. French	10922.67	9271.50	6491.40	-0.96	0.43	2196.00	27387.00	32.19 ***
18	Pr. American 20th post	9003.45	6993.50	5066.87	-1.40	0.42	2512.00	19126.00	52.01 ***
19	Pr. American 20th pre	2553.82	1827.00	1498.28	1.76	1.41	970.00	8198.00	218.58 ***
20	Pr. E&A	14794.70	9570.50	10279.04	-1.07	0.65	2652.00	39196.00	55.28 ***
21	Pr. French 19th	4965.35	4085.00	2336.23	-0.44	0.76	1137.00	11445.00	49.13 ***

22	Pr. German 19th &E20th	2278.80	1404.00	1619.08	-0.03	0.99	330.00	7144.00	76.69 ***
23	Pr. German OM	3948.81	2321.50	2767.61	-0.20	0.89	931.00	12519.00	63.48 ***
24	Pr. Italian 20th	9157.59	6704.00	5823.57	-0.11	1.06	2658.00	25782.00	89.08 ***
25	Pr. Italian OM	1897.38	1708.00	784.82	2.40	1.41	701.00	5172.00	271.84 ***

Notes:
In column "**Art Index name**" if index name begin with "P." it denotes paintings, "S." – sculpultures., "Ph." – photography and "Pr." – prints.
*** - indicates a statistical significance level of 1%.

Source: Own calculations.

The following columns of Table 1 show the names of the studied indices, their average values during the research period, the median values, and the standard deviations. The standard deviation indicates that the greatest variability is characteristic of the indices related to photography investment types. The highest values recorded were for the indices: Photography Contemporary, Photography American, and Photography E&A, which amounted to 36780.49, 16241.80, and 12521.17, respectively. Most kurtosis values are less than zero (applying to 20 indices), indicating that the distribution of these time series is generally flatter than a normal distribution. For all skewness values (excluding Photography Contemporary), values greater than zero are observed, suggesting the indices are skewed to the right. In the following columns, the minimum and maximum values are provided, and the last column displays the Jarque-Bera test statistic, showing that all studied time series are non-normally distributed.

To describe price explosivity episodes in the studied art indices, we use the GSADF (generalised supremum augmented Dickey-Fuller) test (Phillips et al., 2015). We choose this method because the test can detect multiple periods of price explosivity, which is not possible with SADF or ADF tests (Y. Li et al., 2020; Nguyen & Waters, 2022). Additionally, GSADF is a good choice for long time series, which is also important in our case, as we studied 470 monthly observations.

The GSADF test relies on the following recursive regression:

$$y_t = \mu + \beta y_{t-1} \sum_{i=1}^{p} \delta_{(r_2-r_1)} \beta_{y_{t-i}} + \varepsilon_t \qquad (1)$$

Where,

yt – is the art market index value,

μ, β, δ – are model parameters,

p – is the number of lags,

ε_t – is an error term.

Periods of price explosivity are identified using the GSADF and BSADF test statistics (Phillips et al., 2015), which are calculated below:

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_0]}} ADF_{r_1}^{r_2} \qquad (2)$$

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} ADF_{r_1}^{r_2} \qquad (3)$$

Where,

r_1 – is the start point of the test window,

r_2 – is the end point of the test window,

ADF is the value of the augmented Dickey-Fuller test statistic (Dickey & Fuller, 1979). ADF is used to verify the null hypothesis that a unit root exists in the studied time series (non-stationary) against the alternative hypothesis (stationary).

The critical values (cv) for the test statistic are computed using Monte Carlo simulations with 2,000 repetitions, which aligns with research (Nguyen & Waters, 2022; Potrykus, 2023b).

After identifying the periods in which price bubbles were observed, the phi correlation coefficients were calculated for all pairs of the studied indices. The calculations followed the method outlined in (Akoglu, 2018). It should be noted that the phi coefficient ranges from −1 to +1, (Allen, 2017), and based on this, it is possible to evaluate the co-occurrence of price bubbles for the pairs of studied indices.

4. Research results

In the first step of the study, the GSADF test statistic was calculated for each of the 25 analysed time series. The results, along with the statistical significance level, are presented in Table 2.

Table 2 GSADF test results

No.	Investment	GSADF test value
1	Painting Art 100	18.27 ***
2	Painting Contemporary Art	14.24 ***
3	Painting European 19th	13.69 ***
4	Painting Modern Art	23.54 ***
5	Painting Modern European	6.50 ***
6	Painting Old Masters	9.40 ***
7	Sculpture American 20th	9.38 ***

8	Sculpture British 20th	9.21 ***
9	Sculpture Euro. & NA	15.08 ***
10	Sculpture French 19th	15.45 ***
11	Sculpture French Animalier	13.74 ***
12	Sculpture Italian 20th	6.29 ***
13	Photography American	12.71 ***
14	Photography British 19th	9.08 ***
15	Photography Contemporary	5.63 ***
16	Photography E&A	12.86 ***
17	Photography French	6.03 ***
18	Prints American 20th post	14.21 ***
19	Prints American 20th pre	23.23 ***
20	Prints E&A	17.93 ***
21	Prints French 19th	11.8 ***
22	Prints German 19th &E20th	12.13 ***
23	Prints German OM	14.34 ***
24	Prints Italian 20th	8.49 ***
25	Prints Italian OM	5.25 ***

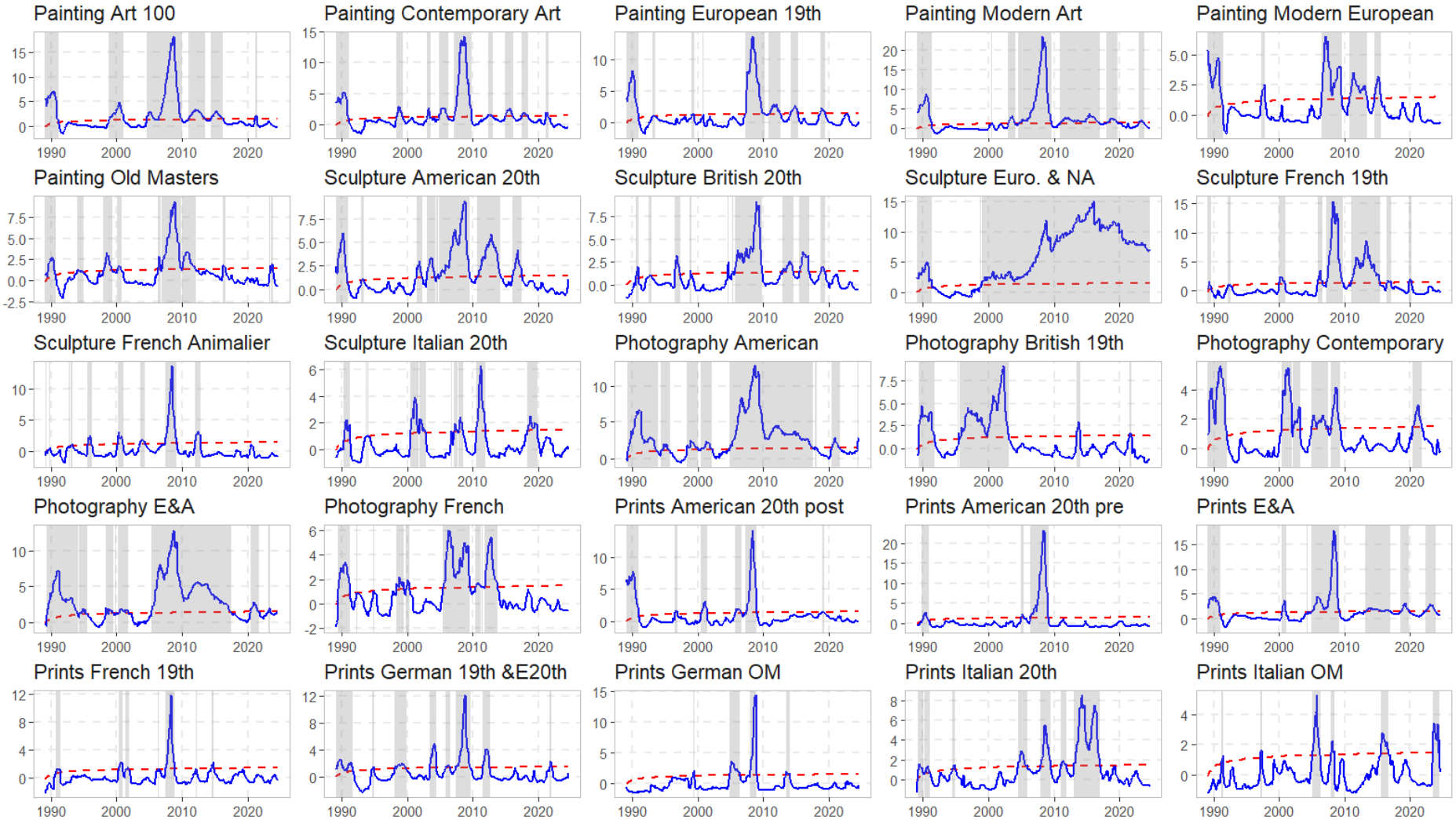
Notes:
*** - indicates a statistical significance level of 1%.
Source: Own calculations.

Based on the data in Table 2, it can be stated that for each analysed time series, the value of the test statistic exceeds the critical value of the test, obtained from the Monte Carlo analysis, for the highest significance level considered, i.e., $\alpha=0.01$. The critical value of the test determined for the level $\alpha=0.01$ is 2.771, and the lowest value of the obtained GSADF test statistic (obtained for Prints Italian OM) was nearly twice as high, amounting to 5.25. This indicates that, for each analysed data series, the presence of periods that can be classified as price bubbles was confirmed. To illustrate which periods within the research timeframe were identified as price bubbles, Figure 1 and Figure 2 are presented below.

In Figure 1, the red dashed line represents the critical value obtained for the GSADF test. The blue line shows the value of the GSADF test statistic. At each point (month) in the research sample, if the test statistic exceeded the critical value, a price bubble was identified. The grey colour on the graphs additionally highlights these periods.

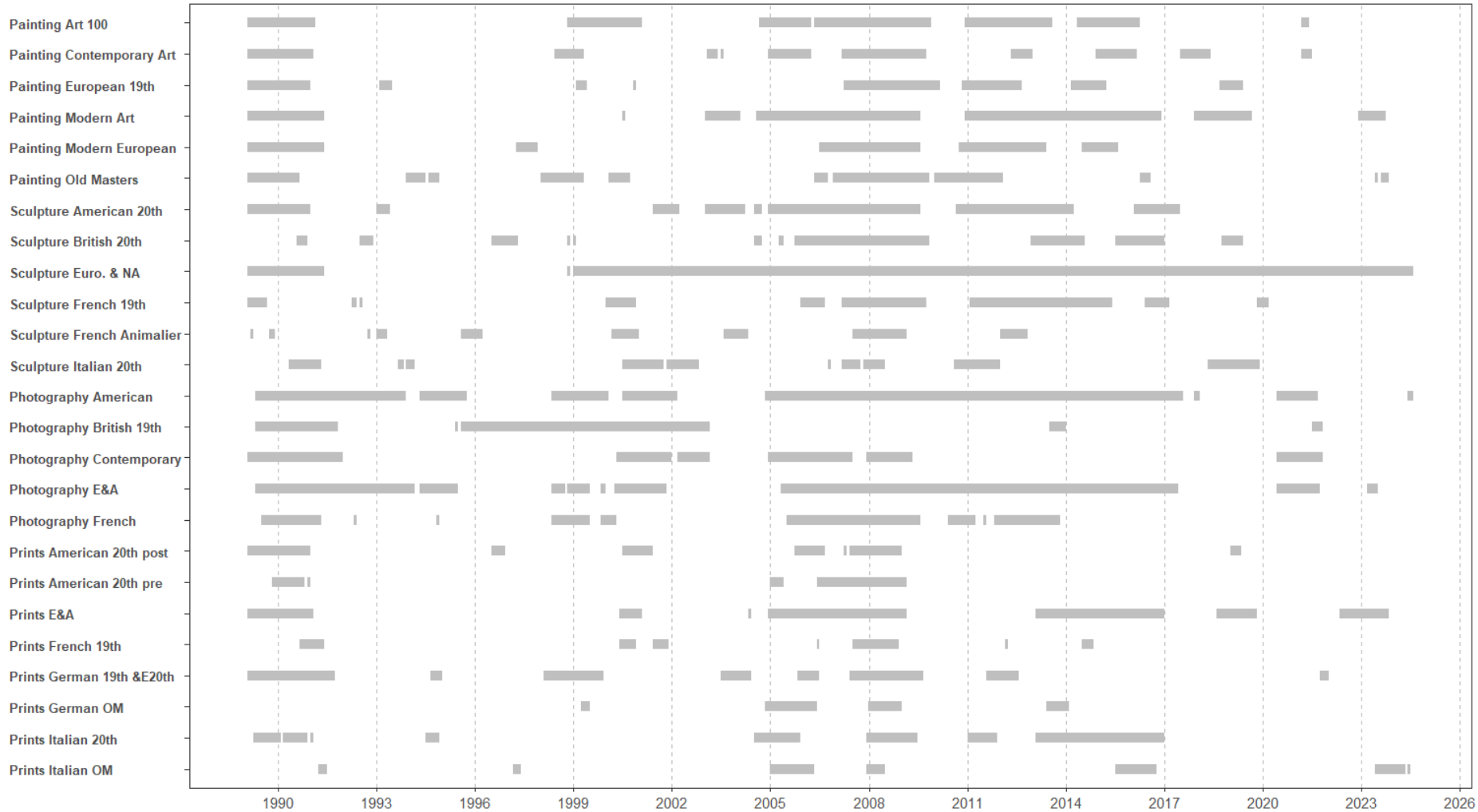
Figure 2 shows all periods identified as price banks on the time axis, to clarify the results presented in Figure 1. Moreover, the data in Figure 2 serve as a starting point for calculating the phi correlation coefficients, which will help assess the co-occurrence of these periods among the studied indices. To determine the phi correlation coefficients, a value of one was assigned to each month where a price bubble was detected, and zero to others. Then, for the resulting binary time series, the phi correlation coefficients were calculated. These results are presented in the second part of the study in Table 4.

Figure 1 Graphical representation of research findings



Notes: The blue line shows the GSADF test value, the dashed line marks the critical values, and the shaded areas indicate periods of price bubbles.
Source: Own calculations.

Figure 2 Results from the data stamping procedure



Notes: The shaded areas indicate periods of price bubbles.
Source: Own calculations.

Table 3 shows basic descriptive statistics for periods of diagnosed price bubbles. The first column indicates the total number of months during which price bubble periods occurred. The highest values were recorded for three indices: Sculpture Euro & NA, Photography American, and Photography E&A, with price bubbles lasting 337, 286, and 271 months respectively. The fewest months of price bubbles occurred for the following indices: Prints German OM (42 months), Prints French 19th (44 months), and Prints American 20th pre (51 months). On average, the fewest months of price bubbles for a single index were seen in the Prints group (83.6 months), followed by Painting (143.2 months) and Sculpture (152.8 months) groups, which showed similar results. The longest average periods for each index were recorded for the Photography group, at 189.8 months.

Tabela 3 Descriptive statistics for periods of diagnosed price bubbles

Investment	Length sum of all periods	Number of detected periods	Average length	Standard deviation	Maximum length	% of time
Painting Art 100	172	7	25	12	43	36.6%
Painting Contemporary Art	125	10	13	9	31	26.6%
Painting European 19th	112	8	14	12	35	23.8%
Painting Modern Art	205	7	29	27	72	43.6%
Painting Modern European	118	5	24	13	37	25.1%
Painting Old Masters	127	11	12	11	35	27.0%
Sculpture American 20th	172	8	22	19	56	36.6%
Sculpture British 20th	121	11	11	14	49	25.7%
Sculpture Euro. & NA	337	3	112	170	308	71.7%
Sculpture French 19th	126	9	14	17	52	26.8%
Sculpture French Animalier	65	9	7	6	20	13.8%
Sculpture Italian 20th	96	10	10	6	19	20.4%
Photography American	286	8	36	50	153	60.9%
Photography British 19th	132	5	26	38	91	28.1%
Photography Contemporary	132	6	22	9	35	28.1%
Photography E&A	271	9	30	46	145	57.7%
Photography French	128	9	14	16	49	27.2%
Prints American 20th post	74	7	11	8	23	15.7%
Prints American 20th pre	51	4	13	14	33	10.9%
Prints E&A	164	7	23	19	51	34.9%
Prints French 19th	44	7	6	6	17	9.4%
Prints German 19th &E20th	119	8	15	11	32	25.3%
Prints German OM	42	4	11	7	19	8.9%
Prints Italian 20th	119	8	15	14	47	25.3%
Prints Italian OM	56	7	8	6	16	11.9%

Source: Own calculations.

The next column of Table 3 displays the total number of price bubbles identified for each index. This number varies from 3 to 11. Interestingly, the fewest bubbles were recorded for the Sculpture Euro. & NA index, which also experienced the highest total number of months with price bubbles. Over the entire review period, more than 10 price bubbles occurred for the indices: Painting Contemporary Art, Sculpture Italian 20th, Painting Old Masters, and Sculpture British 20th. The subsequent columns of Table 3 provide data on the average duration of each price bubble and the standard deviation of these durations. For both of these descriptive statistics, the Sculpture Euro. & NA index also stands out, having the highest values among all studied indices. The smallest variation in bubble duration, 6 months, was observed for the Prints French 19th, Prints Italian OM, Sculpture French Animalier, and Sculpture Italian 20th indices. The final two columns report the maximum length of any diagnosed price bubble and the percentage of time during which price bubbles occurred for each index. Regarding the % duration of price bubbles, the results range from less than 9% for the Prints German OM to nearly 72% for the Sculpture Euro. & NA index. This indicates significant differences among the indices in both the number and length of price bubbles.

In the next stage of the study, it was identified whether price banks for individual index pairs occur in the same periods. To do this, the values of the phi correlation coefficients were calculated, which are shown graphically in Figure 3 and Table 4.

Based on the data shown in Figure 3, it can be said that most of the phi correlation coefficient values are greater than zero. This indicates that if price bubbles occur for one index, then similar periods also happen for the second index. Conversely, when no price bubbles are observed for the first index of the pair, the same pattern is seen for the second index. The highest positive values recorded were for the Photography American and Photography E&A indices (0.84), which suggests a very strong connection. A phi coefficient value exceeding 0.6 was also noted for:

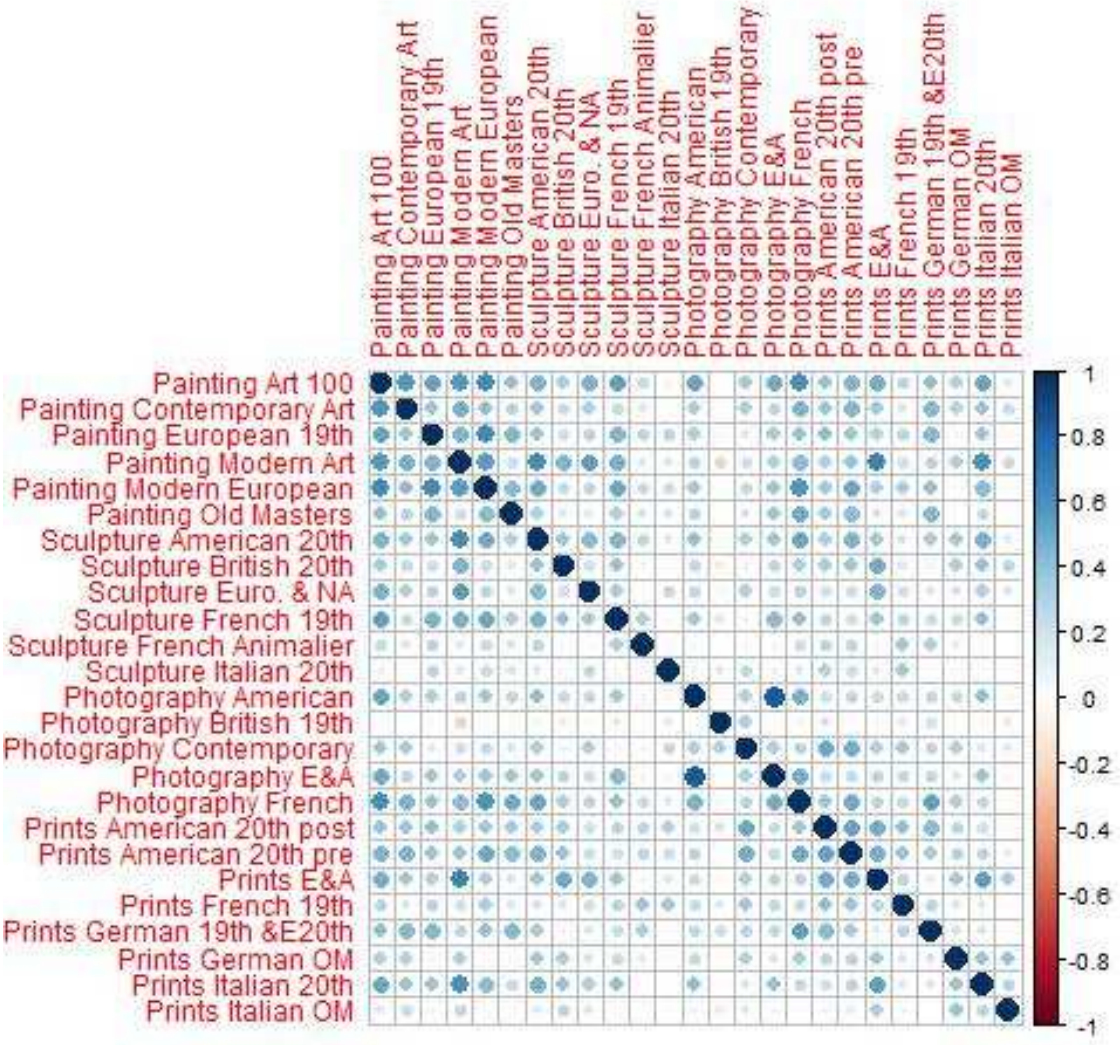
- Painting Modern Art and Prints E&A (0.66).
- Painting Art 100 and Painting Modern European (0.63).
- Painting European 19th and Painting Modern European (0.62).
- Painting Art 100 and Photography French (0.61).
- Painting Modern Art and Sculpture American 20th (0.61).

The lowest values for this coefficient were observed in the following index pairs:

- Photography British 19th and Painting Modern Art (-0.23).
- Photography British 19th and Sculpture French 19th (-0.15).
- Photography British 19th and Prints Italian OM (-0.14).

- Photography British 19th and Sculpture British 20th (-0.13).

Figure 3 Phi correlation coefficient results



Source: Own calculations.

This clearly indicates that the Photography British 19th index is the part of the art market that is least correlated with the other indices examined. This is a valuable hint for investors seeking a diversified investment portfolio that would be resistant to significant fluctuations in value. A negative correlation coefficient phi means that when periods of price bubbles occur for this index, such periods do not occur simultaneously for other art market indices. Furthermore, what is important, in Figure 3 it was not found that the calculated correlation coefficients grouped within the four types of this market examined, namely paintings, sculptures, photography, and prints. The exact results of all calculated phi coefficient values, along with their statistical significance levels, are presented in Table 4.

Table 4 Phi coefficient values with statistical significance

Index number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2	0.57 ***																							
3	0.53 ***	0.39 ***																						
4	0.57 ***	0.47 ***	0.45 ***																					
5	0.63 ***	0.42 ***	0.62 ***	0.56 ***																				
6	0.4 ***	0.3 ***	0.45 ***	0.22 ***	0.42 ***																			
7	0.46 ***	0.36 ***	0.38 ***	0.61 ***	0.5 ***	0.3 ***																		
8	0.33 ***	0.24 ***	0.22 ***	0.45 ***	0.22 ***	0.16 ***	0.38 ***																	
9	0.47 ***	0.31 ***	0.3 ***	0.55 ***	0.28 ***	0.15 ***	0.43 ***	0.21 ***																
10	0.54 ***	0.24 ***	0.45 ***	0.48 ***	0.5 ***	0.32 ***	0.46 ***	0.39 ***	0.35 ***															
11	0.25 ***	0.16 ***	0.28 ***	0.14 ***	0.24 ***	0.19 ***	0.27 ***	0.06	0.07	0.31 ***														
12	0.12 ***	-0.01	0.29 ***	0.17 ***	0.23 ***	0.19 ***	0.15 ***	0.04	0.26 ***	0.07	0.06													
13	0.52 ***	0.32 ***	0.33 ***	0.28 ***	0.35 ***	0.28 ***	0.41 ***	0.26 ***	0.26 ***	0.37 ***	0.07	0.08 *												
14	0.02	-0.02	-0.07	-0.23 ***	0	0.05	-0.1 **	-0.13 ***	-0.09 **	-0.15 ***	0.02	0.14 ***	0.02											
15	0.35 ***	0.33 ***	0.14 ***	0.2 ***	0.26 ***	0.18 ***	0.32 ***	0.11 **	0.32 ***	0.09 **	0.11 **	0.26 ***	0.32 ***	0.3 ***										
16	0.49 ***	0.27 ***	0.36 ***	0.3 ***	0.39 ***	0.38 ***	0.36 ***	0.29 ***	0.23 ***	0.42 ***	0.11 **	0.1 **	0.84 ***	-0.02	0.32 ***									
17	0.61 ***	0.45 ***	0.4 ***	0.43 ***	0.58 ***	0.5 ***	0.52 ***	0.33 ***	0.29 ***	0.41 ***	0.23 ***	0.15 ***	0.46 ***	0.11 **	0.29 ***	0.49 ***								

Index number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
18	0.4 ***	0.39 ***	0.42 ***	0.31 ***	0.36 ***	0.34 ***	0.33 ***	0.33 ***	0.21 ***	0.28 ***	0.28 ***	0.3 ***	0.2 ***	0.2 ***	0.51 ***	0.23 ***	0.38 ***							
19	0.46 ***	0.44 ***	0.38 ***	0.4 ***	0.51 ***	0.42 ***	0.46 ***	0.39 ***	0.22 ***	0.21 ***	0.28 ***	0.21 ***	0.28 ***	-0.02	0.48 ***	0.24 ***	0.49 ***	0.53 ***						
20	0.47 ***	0.36 ***	0.31 ***	0.66 ***	0.33 ***	0.19 ***	0.36 ***	0.5 ***	0.46 ***	0.37 ***	0.09 **	0.15 ***	0.24 ***	-0.11 **	0.32 ***	0.28 ***	0.27 ***	0.48 ***	0.48 ***					
21	0.29 ***	0.17 ***	0.28 ***	0.2 ***	0.34 ***	0.17 ***	0.2 ***	0.18 ***	0.2 ***	0.28 ***	0.38 ***	0.36 ***	0.24 ***	0.14 ***	0.35 ***	0.26 ***	0.25 ***	0.4 ***	0.38 ***	0.27 ***				
22	0.41 ***	0.44 ***	0.43 ***	0.29 ***	0.41 ***	0.44 ***	0.35 ***	0.12 **	0.17 ***	0.23 ***	0.32 ***	0.06	0.27 ***	0.2 ***	0.28 ***	0.25 ***	0.53 ***	0.42 ***	0.35 ***	0.13 ***	0.28 ***			
23	0.3 ***	0.3 ***	0.07	0.31 ***	0.03	0.04	0.35 ***	0.33 ***	0.2 ***	0.25 ***	0.13 ***	-0.05	0.25 ***	-0.05	0.3 ***	0.18 ***	0.33 ***	0.27 ***	0.3 ***	0.37 ***	0.18 ***	0.19 ***		
24	0.51 ***	0.38 ***	0.39 ***	0.59 ***	0.42 ***	0.24 ***	0.46 ***	0.4 ***	0.31 ***	0.41 ***	0.01	0.02	0.42 ***	-0.09 **	0.17 ***	0.39 ***	0.26 ***	0.21 ***	0.28 ***	0.54 ***	0.15 ***	0.19 ***	0.38 ***	
25	0.14 ***	0.22 ***	-0.1 **	0.26 ***	-0.03	0	0.14 ***	0.28 ***	0.17 ***	0.01	-0.01	-0.06	0.11 **	-0.14 ***	0.15 ***	0.08	0.04	0.09 **	0.13 ***	0.32 ***	0.08 *	0.03	0.39 ***	0.28 ***

Source: Own calculations.

The data in Table 4 support the statement that, on average, periods of price bubbles occur simultaneously across the studied indices. The average value of the phi correlation coefficient was approximately 0.30. The indices least related to others in terms of the co-occurrence of price bubbles were: Photography British 19th, Prints Italian OM, and Sculpture Italian 20th. Investments in these indices should be valuable for art market investors when combined with other investments in this market, helping to minimise extreme fluctuations in the value of the investment portfolio.

5. Conclusion

Based on the research conducted, it was found that all 25 examined indices, including those for investing in paintings, sculptures, photography, and prints markets, exhibit periods of price bubbles. This was confirmed at the highest significance level of α=0.01. It was demonstrated that the duration of price bubbles varies significantly among the examined indices, ranging from less than 10% (for the Prints German OM and Prints French 19th indices) to over 50% (for the Photography E&A, Photography American, and Sculpture Euro & NA indices). The average duration across all indices was 28.9%, placing art market investments on a similar level to investing in investment wines (Potrykus, 2023a). The periods identified in the art markets were also, on average, longer than those in precious and industrial metals (Ozgur et al., 2021), diamond investments (Potrykus, 2022), or cryptocurrencies (Bouri et al., 2019). This pattern likely relates to the market's low liquidity. Additionally, it was shown that the art market tends to have a positive co-occurrence of price bubbles. In most of the studied index pairs, the phi correlation coefficient was positive, averaging close to 0.30. Furthermore, stronger co-occurrence of bubbles was not confirmed within the same groups—namely, paintings, sculptures, photography, and prints. The Photography British 19th index was also highlighted as significant for investment portfolio diversification, characterised by the lowest (often negative) phi coefficient values.

The conclusions drawn from the above study are valuable for both individual and institutional investors, as well as for market analysts or investment fund managers. In the next phase of the research, it would be necessary to deepen the investigation into the co-occurrence of price bubbles, for example, by using logistic regression methods or random forests.

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Appendix

Table A1 Full names of the indices studied

No.	Category	Full name	Short name
1	Painting	Art 100 Index	Art 100
2	Painting	Contemporary Art 100 Index	Contemporary Art
3	Painting	European 19th Century Art 100 Index	European 19th
4	Painting	Modern Art 100 Index	Modern Art
5	Painting	Modern European Painting	Modern European
6	Painting	Old Masters 100 Index	Old Masters
7	Sculpture	American 20th-Century Sculpture	American 20th
8	Sculpture	British 20th-Century Sculpture	British 20th
9	Sculpture	European & North American Sculpture 100 Index	Euro. & NA
10	Sculpture	French 19th-Century Sculpture	French 19th
11	Sculpture	French Animalier Sculpture	French Animalier
12	Sculpture	Italian 20th-Century Sculpture	Italian 20th
13	Photography	American Photography	American
14	Photography	British 19th-Century Photographers	British 19th
15	Photography	Contemporary Photography 50	Contemporary
16	Photography	European & American Photography 100 Index	E&A
17	Photography	French Photography	French
18	Prints	American 20th-Century Print-Makers [mainly post-1950]	American 20th post
19	Prints	American 20th-Century Print-Makers [mainly pre-1950]	American 20th pre
20	Prints	European & American Print 100 Index	E&A
21	Prints	French 19th-Century Print-Makers	French 19th
22	Prints	German 19th-Century and Early 20th-Century Print-Makers	German 19th &E20th
23	Prints	German Old Master Print-Makers	German OM
24	Prints	Italian 20th-Century Print-Makers	Italian 20th
25	Prints	Italian Old Master Print-Makers	Italian OM